

Using SIMMOD and taking into account the factors discussed in the previous section, this section describes the existing runway and airspace conditions at the three Bay Area airports, and quantifies the delays determined through simulation for 1999. These delays can then be compared to actual delays experienced at the three airports, in order to validate the model.

3.1 EXISTING AIRCRAFT OPERATIONS AND AIRLINE FLIGHT SCHEDULES

Data for 1999, as logged by the control tower, were used as input to the simulation to provide the number of aircraft operations (each arrival or departure is one operation), the schedule of arrivals and departures, the types of aircraft, and the origin/destination of each aircraft. This data is developed as a flight schedule over the full 24 hours of airport operations for the average day of the peak traffic month (ADPM) which was a mid-week day in August 1999. Figures 3-1, 3-2 and 3-3 show graphically the 1999 flight schedules for each of the three airports involved in the simulations.

3.1.1 SFO Flight Schedule

As shown in Figure 3-1, the ADPM flight schedule includes about 1241 daily arrivals and departures. Ninety percent of the flights are commercial passenger aircraft, 5% are all-cargo flights and 5% are general aviation flights. The arrival peak occurs from 11AM to 12PM, when 45 flights land. The departure peak occurs from 1PM to 2PM when 46 flights take off. Overall, from 7AM to 9PM the number of operations falls in a relatively narrow range (66-88 ops/hour) and is a pattern typical of a mature airport operating near capacity.

3.1.2 OAK Flight Schedule

As shown in Figure 3-2, the ADPM flight schedule includes about 548 daily arrivals and departures for the South Field. Sixty-three percent of the flights are commercial passenger aircraft, 24% are all-cargo flights and 13% are general aviation flights. The arrival peak occurs from 5 p.m. to 6 p.m., when 20 flights arrive. The departure peak occurs from 6 a.m. to 7 a.m. when 26 flights depart. The reason for the imbalance between arrivals and departures is that some cargo aircraft use the North Field for landing and therefore do not appear in the graph below.

3.1.3 SJC Flight Schedule

As shown in Figure 3-3, the ADPM flight schedule for the main air carrier runway includes about 473 daily arrivals and departures. Seventy-nine percent of the flights are commercial passenger aircraft, 6% are all-cargo flights, and 15% are general aviation flights. The busiest arrival peak occurs from 7PM to 8PM, when 19 flights arrive. The busiest departure peak occurs from 6AM to 7AM when 24 flights depart.

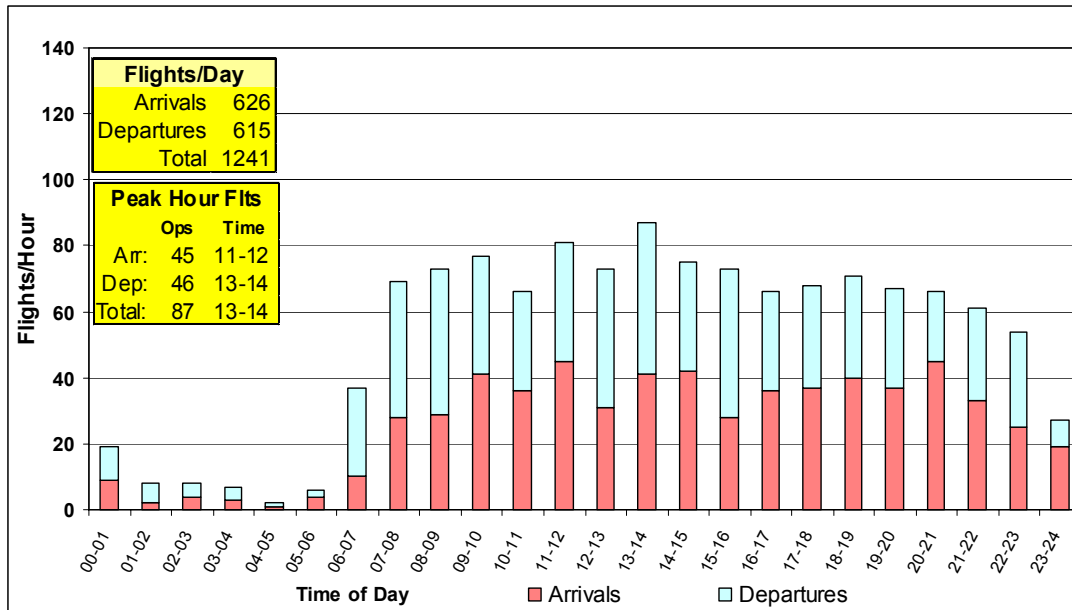


Figure 3-1 SFO Hourly Traffic Demand – Mid-week August 1999

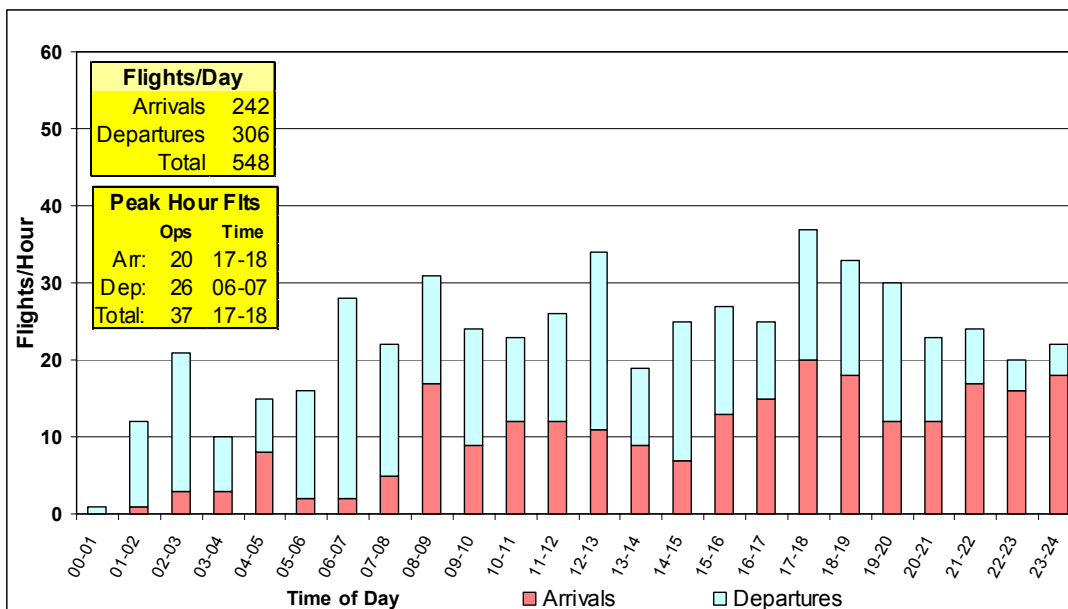


Figure 3-2 OAK Hourly Traffic Demand – Mid-week August 1999

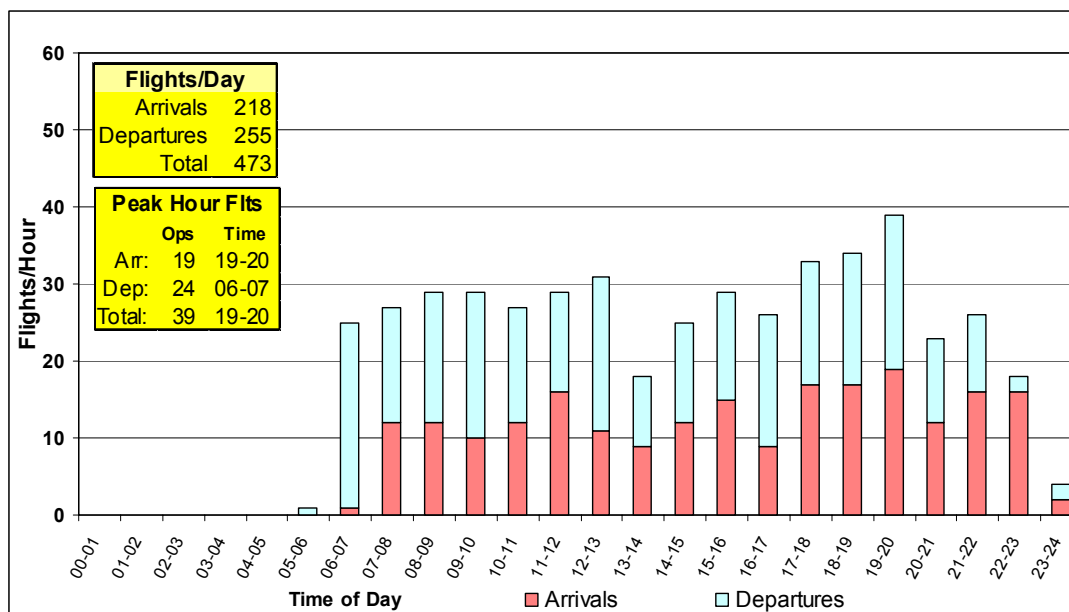


Figure 3-3 SJC Hourly Traffic Demand – Mid-week August 1999

3.2 EXISTING RUNWAY LAYOUTS AND OPERATING PROCEDURES

To determine the baseline of capacity and delay, the existing airport runway layouts for SFO, OAK, and SJC were modeled in SIMMOD. Figures 3-4, 3-5, and 3-6 show the existing runway/taxiway configuration of each airport.

Two basic airspace flow plans are used by air traffic control (ATC) to guide aircraft into and out of the three Bay Area airports, the West Plan and the Southeast Plan. The West Plan is used about 95% of the time and responds to the prevailing winds in the Bay Area which generally blow from a westerly direction. The Southeast plan is used only when strong winds (above 20 knots) blow from the southeast, which generally occurs during winter storms. The preferred approach/departure procedures for each traffic flow plan are shown in the figures below.

3.2.1 SFO Runway Configuration and Operating Procedures

As shown in the figure below, the existing runway configuration is composed of two close parallel runways oriented in an east-west direction (runway 10L/28R and runway 10R/28L); the runways are intersected by two close parallel runways oriented in a north-south direction (runway 1L/19R and runway 1R/19L).

Each pair of runways is categorized by the FAA as closely spaced since they are separated by only 750 feet measured between runway centerlines. During good weather conditions when VFR is used, two independent streams of arrivals can be sequenced on the closely spaced pairs of runways. However, during IFR conditions of low ceiling and poor visibility, only one stream of

arrivals can be handled safely, cutting runway capacity in half. For departures, two streams can be handled safely in VFR conditions. In IFR conditions, paired departures are permitted if visual separation can be maintained until aircraft have a 15 degree diverging heading and are established on course. Otherwise, departure procedures require a 1 mile staggered separation distance for diverging heading, a 3 to 5 mile separation with standard radar depending upon aircraft fleet mix (heavy vs. non-heavy aircraft), or a 5 mile radar separation if small follows heavy. Procedures used during VFR and IFR conditions for both the West Plan and Southeast plans are shown below.

For the West Plan VFR shown in Figure 3-4 A, the following procedures are typically followed:

- Arriving flights on 28L and 28R are paired for simultaneous landings, and each pair of aircraft must follow about 4 nm apart. This leaves sufficient space to allow a pair of aircraft to depart on these runways.
- Departures on 1R and 1L can be released only after arriving flights have crossed runway 1L.
- Departures for long-haul heavy flights must take place on 28R because of its length. These departures must be sequenced in a free slot of the 28R arrival stream.

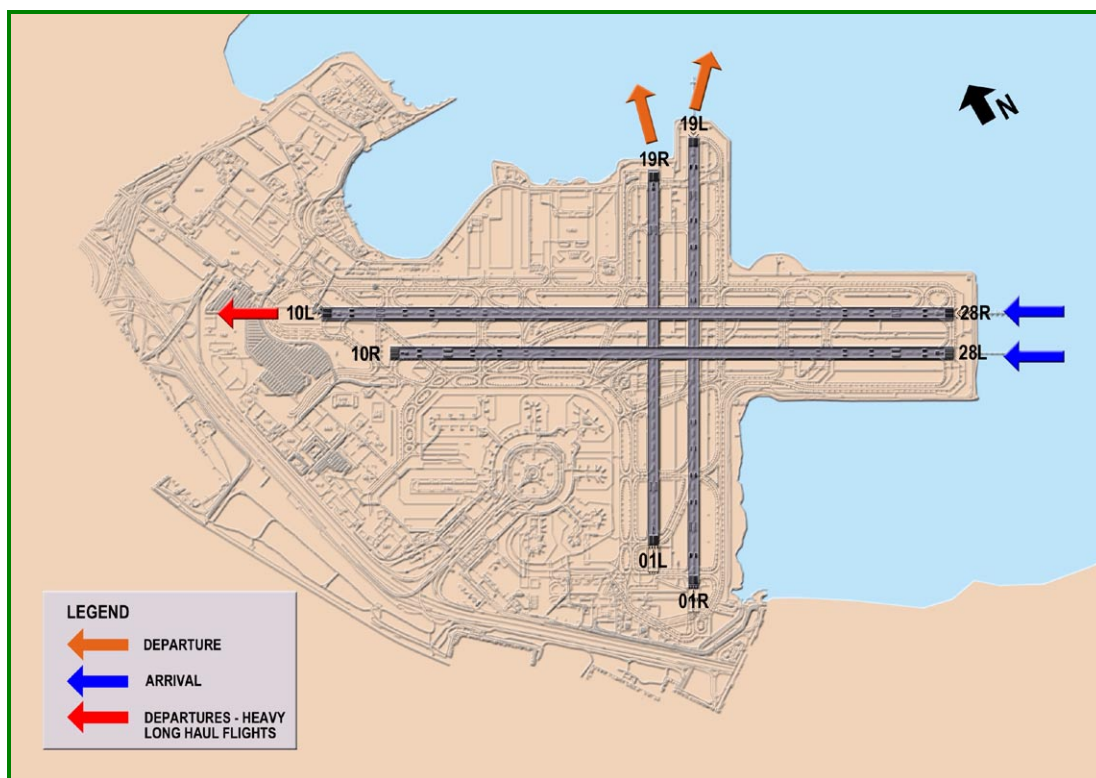


Figure 3-4A Existing SFO Airport Configuration with West Plan VFR Procedures

For the West Plan IFR shown in Figure 3-4 B, the following procedures are typically followed:

- During IFR conditions, arriving flights are restricted to a single runway, and use 28R because that runway is equipped with Category II and III Instrument Landing Systems (ILS).
- Arriving flights on 28R are separated from 4 to 6 nm depending on aircraft size and wake turbulence separation requirements.
- Departing flights use 1L and 1R and must be sequenced between flights arriving on 28R.
- Departures for long-haul heavy flights must take place on 28R because of its length. These departures must be sequenced in a free slot of the 28R arrival stream.

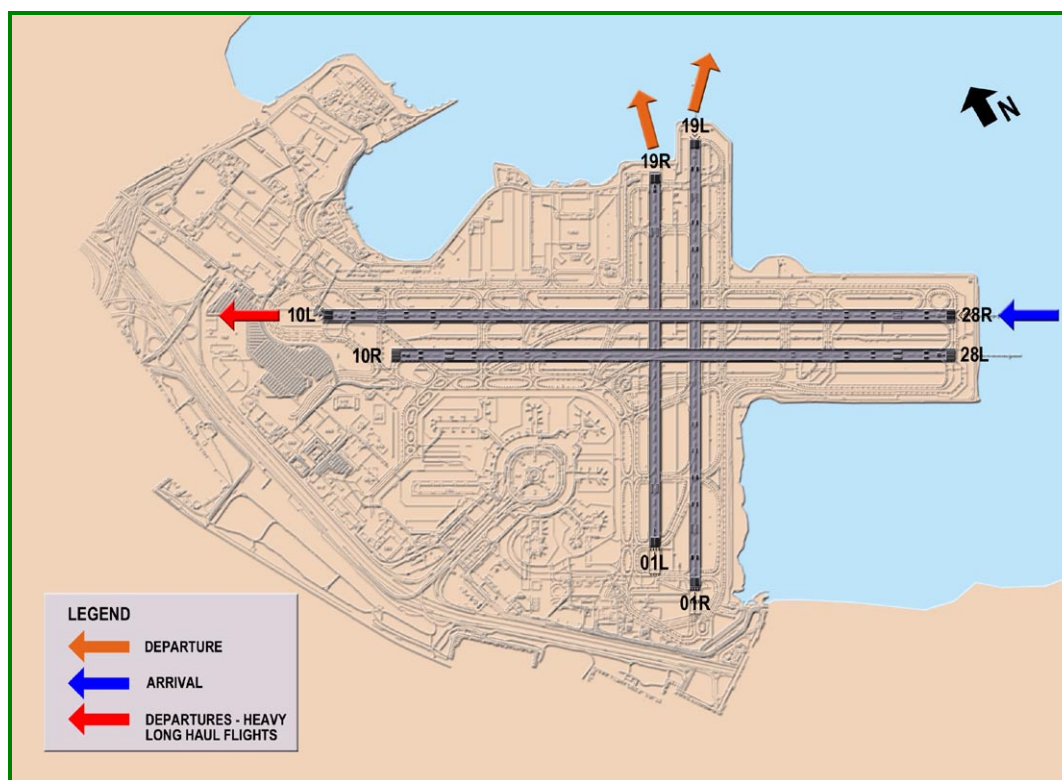


Figure 3-4B Existing SFO Airport Configuration with West Plan IFR Procedures

For the Southeast Plan IFR shown in 3-4 C, the following procedures are typically followed:

- The Southeast Plan is implemented when prevailing storm winds create a southerly crosswind of 20 knots or greater, affecting landings on runways 28L and 28R.
- In the Southeast Plan, arriving flights are limited to a single runway and use runway 19L because it has Category II and III ILS. Arriving flights are separated according to wake turbulence requirements.
- Departing flights use runways 10L and 10R in a staggered way because the departing routes do not diverge sufficiently. This becomes equivalent to a single runway.

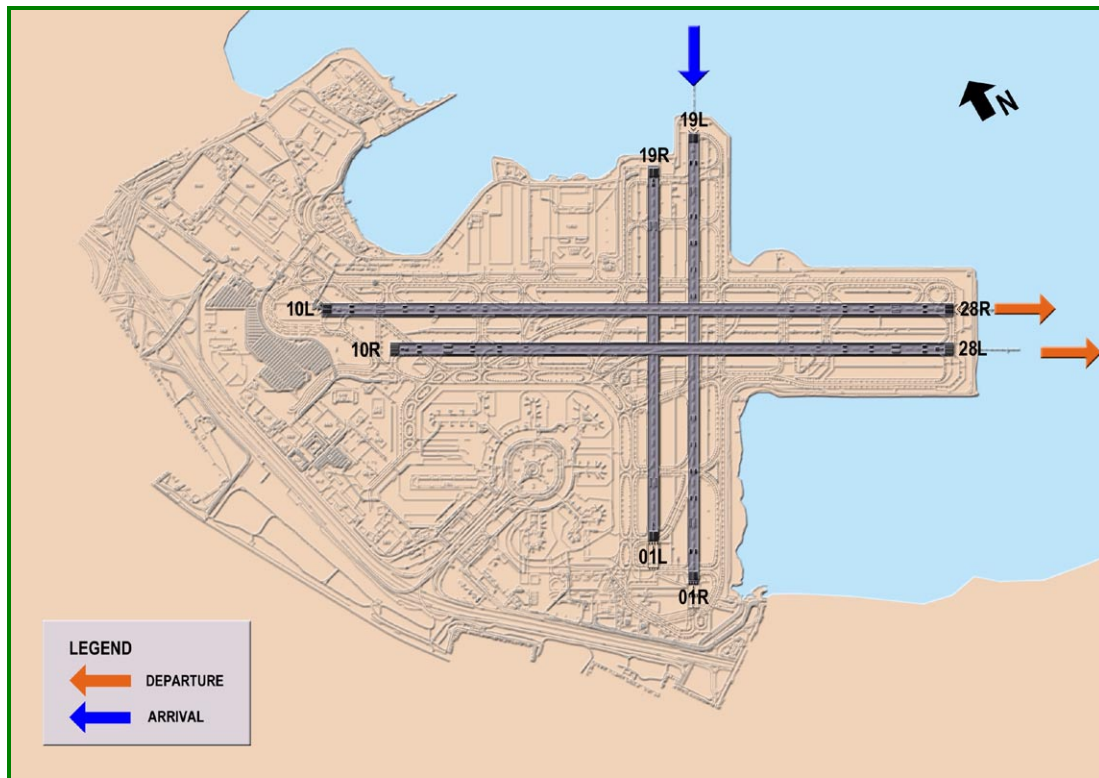


Figure 3-4C Existing SFO Airport Configuration with SE Plan IFR Procedures

3.2.2 OAK Runway Configuration and Operating Procedures

As shown in Figure 3-5, OAK has a single commercial air carrier runway in the South Field (runway 11/29), with a length of 10,000 feet. It also has three shorter runways in the North Field, used primarily for general aviation operations. However, 27R can be used for landing small cargo aircraft and thus does contribute to commercial aircraft capacity. Since there is only a single commercial air carrier runway at OAK, the following operating procedures for both VFR and IFR conditions are typically followed:

- Arriving flights use runway 11/29, separated according to wake turbulence requirements. In the West Plan runway 29 and 27R are used.
- Departing flights use runway 11/29, sequenced between arriving flights according to wake turbulence requirements.

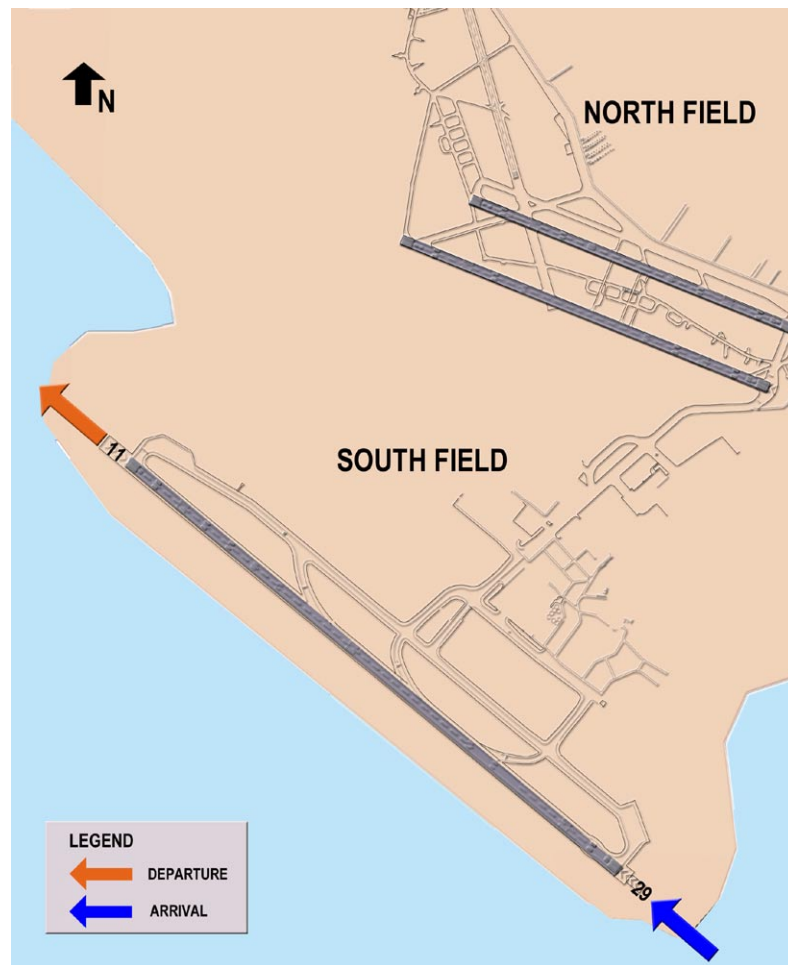


Figure 3-5 OAK Existing Airport Configuration

3.2.3 SJC Runway Configuration

As shown in Figure 3-6, SJC presently has a single commercial air carrier runway (runway 30L/12R) with a length of 10,200 feet. In addition, there are two shorter runways used for general aviation operations that do not affect commercial air carrier capacity. Since there is only a single commercial carrier runway, the following operating procedures for both VFR and IFR conditions are typically followed:

- Arriving flights use runway 12/30, separated according to wake turbulence requirements.
- Departing flights use runway 12/30, sequenced between arriving flights according to wake turbulence requirements.

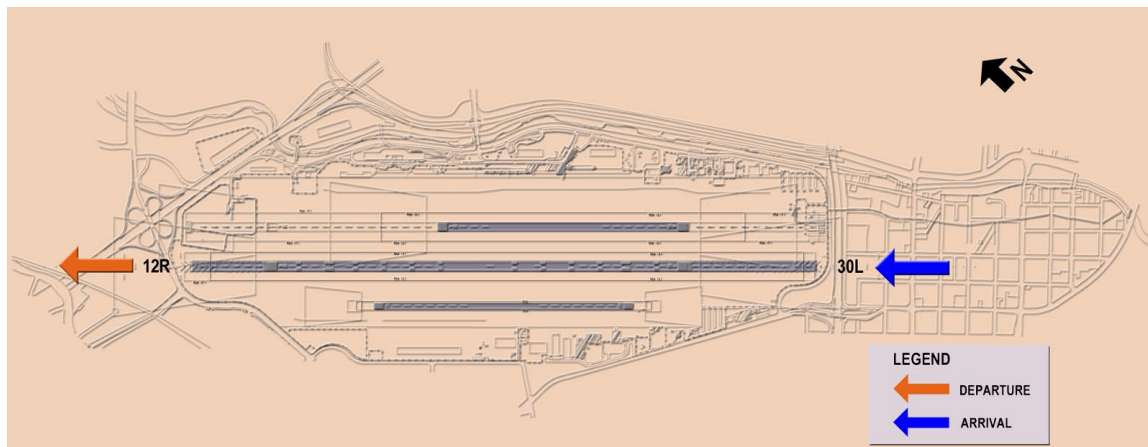


Figure 3-6 SJC Existing Airport Configuration

3.3 EXISTING AIRSPACE STRUCTURE

In the Bay Area, arrivals and departures occur in almost all directions. The east and south sectors are the busiest because they serve US domestic flights and Southern California flights. Detailed airspace routes and procedures have been developed to guide aircraft to/from the appropriate runways at each of the airports under the West and Southeast Plan operating conditions.

3.3.1 West Plan

As shown below in a diagram developed by the San Francisco International Airport, the three-dimensional interaction of approaches and departures at the three airports is tightly controlled by the Oakland ARTCC, the Bay TRACON and the control tower of each airport. The air routes with their fixes and merge points have been incorporated in the simulation utilizing the procedures specified by ATC.

3.3.2 Southeast Plan

As shown in Figure 3-8 below, the existing air routes for the Southeast Plan are used when strong winds from the southeast make use of the West Plan inadvisable. The routes and procedures have been modeled in the simulation of the Southeast Plan.

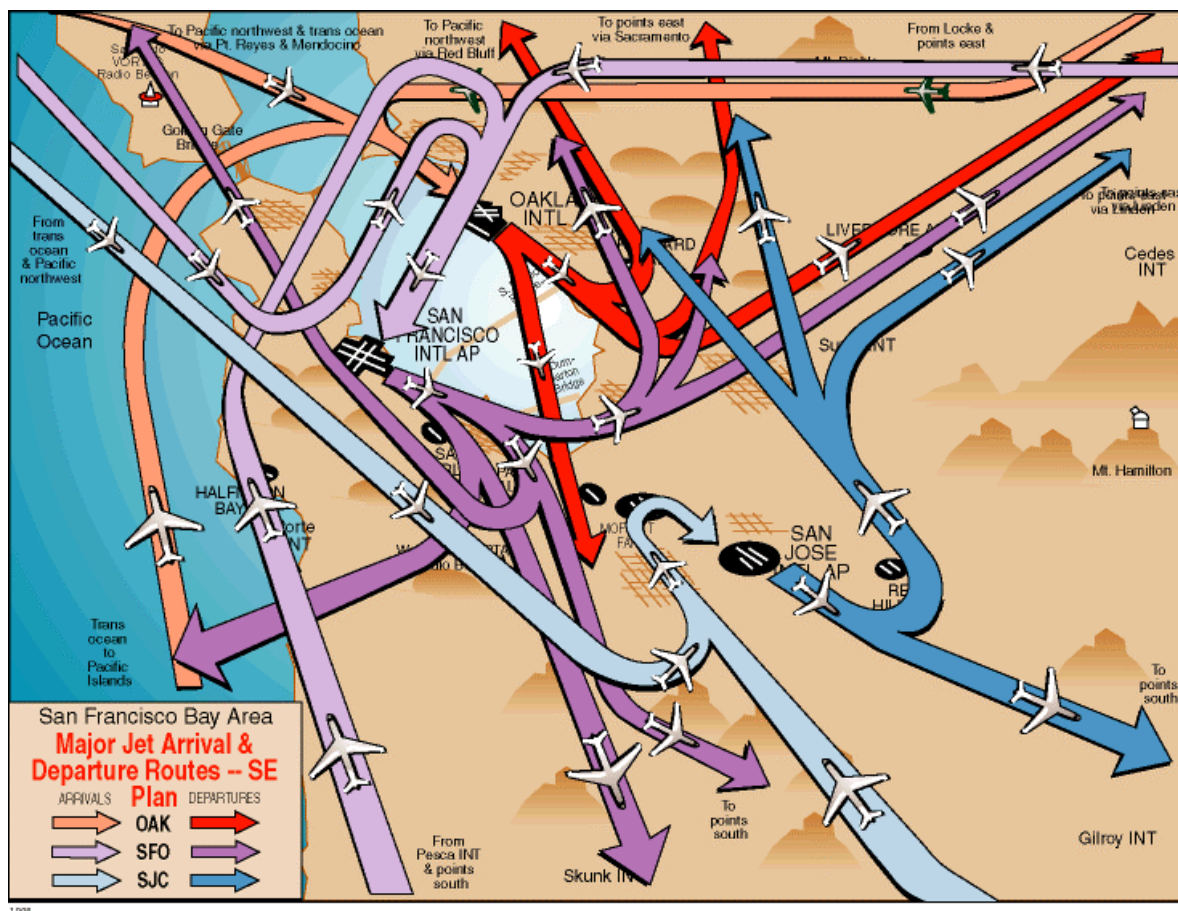


Figure 3-8 Airspace Diagram-Southeast Plan

Source: SFO Planning Department

3.4 SIMULATION RESULTS – ANNUAL DELAYS 1999

The results of the simulation runs are shown below for each airport.

Annual average delays are shown in minutes-per-aircraft for 1999 by one of the three weather-related conditions as follows:

- West Plan VFR: this condition occurs about 80% of the time annually
- West Plan IFR: this condition occurs about 15% of the time annually
- Southeast Plan IFR: this condition occurs about 5% of the time annually

Delays may occur in both arrivals and departures. Delays are quantified in different segments of a flight, including:

- Air: delays by aircraft in flight within the Oakland ARTCC airspace only. In reality, during bad delays at SFO, flights can be held at origin airports, delayed while en route or even cancelled.
- Ground: may include taxi-in, taxi-out, or gate hold delays
- Queue: for departures only, aircraft may be held in a queue awaiting a slot for take-off

As shown in Figure 2-2, average delays of 3 - 5 minutes or less per operation are considered acceptable.

3.4.1 SFO Delays

As shown in Table 3-1, the results of the simulation indicate that for West Plan VFR, which is utilized about 80% of the year, arrival delays are acceptable, averaging about 3.99 minutes per flight. Departure delays, however, average about 6.07 minutes per flight, a bit above acceptable limits. In total, the combined average for West Plan VFR arrivals and departures is about 3.51 minutes per flight, close to acceptable limits.

Table 3-1
SFO Delays-1999

Runs	Arrival Delays (min)				Departure Delays (min)					Total Delays	
	No. Ops	Air	Ground	Total	No. Ops	Air	Ground	Queue	Total	No. Ops	Total
West VFR	626	2.31	0.00	2.31	615	0.31	0.01	4.60	4.74	1241	3.51
West IFR	626	149	0.00	149	615	0.03	0.01	5.73	5.78	1241	77.80
SE IFR	626	93.7	0.02	93.7	615	2.15	0.00	6.45	8.61	1241	51.54
All Plans*				28.99					5.10		17.15

*Weighted average based on the percentage of time each operating plan is utilized on an annual basis

For West Plan IFR, however, which is used about 15% of the year during poor weather visibility, the arrival delays rapidly escalate. This is due to the severe restrictions on capacity imposed when arrivals must be reduced to a single runway. Here, delays keep growing throughout the day. The simulation indicates that, under 1999 traffic levels, average arrival delays mount to almost 149 minutes per flight. Such extreme delays frequently lead to outright flight cancellations or diversion to alternate airports. Average departure delays rise to 5.78 minutes per flight.

For Southeast Plan IFR, which is used about 5% of the year during poor weather visibility when strong winds blow from the southeast, runway use is again effectively restricted to a single runway, leading to extensive delays in both arrivals and departures. For arrivals, the delays

mount to 93.7 minutes per flight and for departures to 8.61 minutes per flight. The arrival delays represent extreme delays that may lead to flight cancellations or diversions.

As a final measure of overall delay, the weighted average of delays under all three weather conditions was calculated based on their annual utilization. The weighting represents West Plan VFR (80%), West Plan IFR (15%) and Southeast Plan IFR (5%), giving a weighted average of 28.99 minutes for arrivals, 5.10 minutes for departures and a combined average of arrival and departure delays of 17.15 minutes.

3.4.2 OAK Delays

As shown in Table 3-2, the annual delays at Oakland with 1999 levels of traffic for West Plan VFR and West Plan IFR fall well under acceptable limits. For the Southeast Plan IFR, arrival delays add up to 1.58 minutes per flight while departure delays mount to 3.80 minutes per flight. During IFR conditions, some commercial aircraft that normally land on the North Field have to use the South Field. In order to mirror actual conditions, the model approximates this impact by increasing aircraft separation during IFR on the South Field.

Table 3-2
OAK Delays-1999

Runs	Arrival Delays (min)				Departure Delays (min)					Total Delays	
	Ops	Air	Ground	Total	Ops	Air	Ground	Queue	Total	Ops	Total
West VFR	242	0.51	0.00	0.51	306	0.11	0.00	1.02	1.13	548	0.86
West IFR	242	1.14	0.00	1.14	306	0.09	0.00	0.79	0.88	548	0.99
SE IFR	242	1.58	0.00	1.58	306	2.87	0.00	0.92	3.80	548	2.82
All Plans*				0.65					1.25		0.99

*Weighted average based on the percentage of time each operating plan is utilized on an annual basis

3.4.3 SJC Delays

As shown in Table 3-3, delays for West Plan VFR and IFR fall well under acceptable minimums. Under the Southeast Plan, arrival delays add up to 1.50 minutes while departure delays mount to 4.33 minutes per flight, still within acceptable limits.

Table 3-3
SJC Delays-1999

Runs	Arrival Delays (min)				Departure Delays (min)					Total Delays	
	Ops	Air	Ground	Total	Ops	Air	Ground	Queue	Total	Ops	Total
<i>West VFR</i>	218	0.63	.000	0.63	255	0.52	0.70	0.80	2.02	473	1.38
<i>West IFR</i>	218	0.52	0.00	0.52	255	0.43	0.63	0.85	1.90	473	1.26
<i>SE IFR</i>	218	1.50	0.00	1.50	255	3.12	0.00	1.21	4.33	473	3.03
<i>All Plans</i>				0.69					2.20		1.50

*Weighted average based on the percentage of time each operating plan is utilized on an annual basis

3.5 MODEL VALIDATION

The model accurately reflects the conditions and delays experienced at the three airports during actual operations in 1999. With the SIMMOD model now tested and validated, it was possible to undertake the modeling of future conditions for 2010 and 2020 as described in Sections 4 and 5.